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ABSTRACT

Any educational technology is only as good as the way it is used for learning. There are many different instructional models using many different types of software, and not all models are equally effective in meeting users' needs. This Technical Paper begins with an overview of ways computer technologies can be used in instruction, and groups them according to the role they play in instruction, as supplementary, complementary, and primary. Then four "generic" instructional models for PLATO[R] are presented: Review/Reinforcement (supplementary: software that adds little or no new content and parallels teaching already done in other modes); Enrichment/Exploration (complementary: software that adds new content to the curriculum, often in ways for which there is no non-computer alterative); Problem-Centered (complementary); and Skill Development System (primary: software that acts as the main source of initial teaching, as a replacement for non-electronic modes of instruction, often as a way of enabling the instructor to assume new "guide on the side" roles, or in distance education). For each of the four models, answers are included to six basic questions that address: the learning goal of the technology application; how to assign learners to use the technology; what the learner's role will be; what the instructor's role and program structure will be; how the resources will be managed; and how the learners will be assessed. At the end is a comparison chart highlighting the features of the four models. (AEF)

PLATO®

Instructional Models

Four Ways to Integrate PLATO Into the Curriculum
Technical Paper #6

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Executive Summary

Any educational technology is only as good as the way it is used for learning. There are many different instructional models using many different types of software, and not all models are equally effective in meeting your needs. We begin with an overview of ways computer technologies can be used in instruction. We group them according to the role they play in instruction, as supplementary, complementary, and primary.

Then, we present four "generic" instructional models for PLATO. The four models are:

- Review/Reinforcement (Supplementary)
- Enrichment/Exploration (Complementary)
- Problem-Centered (Complementary)
- Skill Development System (Primary)

For each of the four models, we include answers to six basic questions. At the end is a comparison chart highlighting the features of the four models.

This technical paper accompanies Technical Paper #5, A Guide for Planning Technology Implementation.

Table of Contents

1. Introduction

Perhaps the most difficult challenge for instructors using technology is to develop a strategy for integrating it into the curriculum. To do so, you need to answer these questions:

1. ***What is the learning goal of the technology application?***

You need to decide on details of exactly what parts of the curriculum will be taught to which learners using technology, based on your analysis of your general goals for program improvement, and the kinds of software you want, based on your analysis of software types available and resource requirements for them.

2. ***How will we assign learners to use the technology?***

Some instructional models assume everyone will be doing the same thing at the same time. Others require sophisticated individualized learning plans (ILP's) based on an assessment of individual needs. In these cases, placement of the each learner in the right assignment, on a daily basis, should be an important factor in your planning.

3. ***What will the learner's role be?***

Instructional models vary widely in how much and what kind of decisions the learners make about their own learning. Some models require solo, self-paced work, while others require collaborative study with everyone studying the same thing at the same time. It's important to work out in detail what the learner's responsibilities will be and how they will be fulfilled.

4. ***What will the instructor's role and program structure be?***

Once the learner's role is defined, then it's necessary to plan your role in teaching, and the overall program structure, so that both will lead the learners through the intended learning processes.

5. How will we manage the resources?

Your technology plan should have identified the general level of hardware and software resources you will need for the number of learners and type of use you have in mind. With the decisions made about curriculum and instruction, you can make a detailed plan for how to schedule and manage the hardware and software resources.

6. How will we assess the learners?

You also need to decide how you will find out what the learners have learned as they have used the technology. For example, PLATO has a range of powerful assessment options built in. Other software sometimes leaves assessment as a task entirely for the instructor. In some settings, an important part of the assessment system is assignment of letter or numeric grades and course credit.

To answer these questions, we first need to look at all the ways technology can be used in instruction. We'll group the various applications using three terms: *supplementary, complementary*, and *primary*.

The major part of this paper presents four "generic" instructional models for PLATO. The four models are:

- Review/Reinforcement (Supplementary)
- Enrichment/Exploration (Complementary)
- Problem-Centered (Complementary)
- Skill Development System (Primary)

For each of the four models, we include answers to the six questions above. For ease of reference, we have included information in each model, even if it is redundant across more than one of the models. Of course, there are many different instructional models using many different types of software, and not all models are equally effective in meeting your needs. The four models presented here are intended to serve as a starting point for you to develop instructional models with PLATO which meet your needs.

2. A Taxonomy of Instructional Software Types

The following overview of the types of educational software may be useful. The diagrams below group the software under three general categories:

- *Supplementary*: Software which adds little or no new content, and parallels teaching already done in other modes. Examples include electronic alternatives to textbooks, lectures, workbooks, references, etc.
- *Complementary:* Software which adds new content to the curriculum, often in ways for which there is no non-computer alternative.
- *Primary:* Software which acts as the main source of initial teaching, as a replacement for non-electronic modes of instruction, often as a way of enabling the instructor to assume new "guide on the side" roles, or in distance education.

A given software product (including PLATO) can often be used in more than one of the three ways, so notice that these definitions characterize the *way* in which software is used as much as *how* the software is designed.

Details of each type follow.

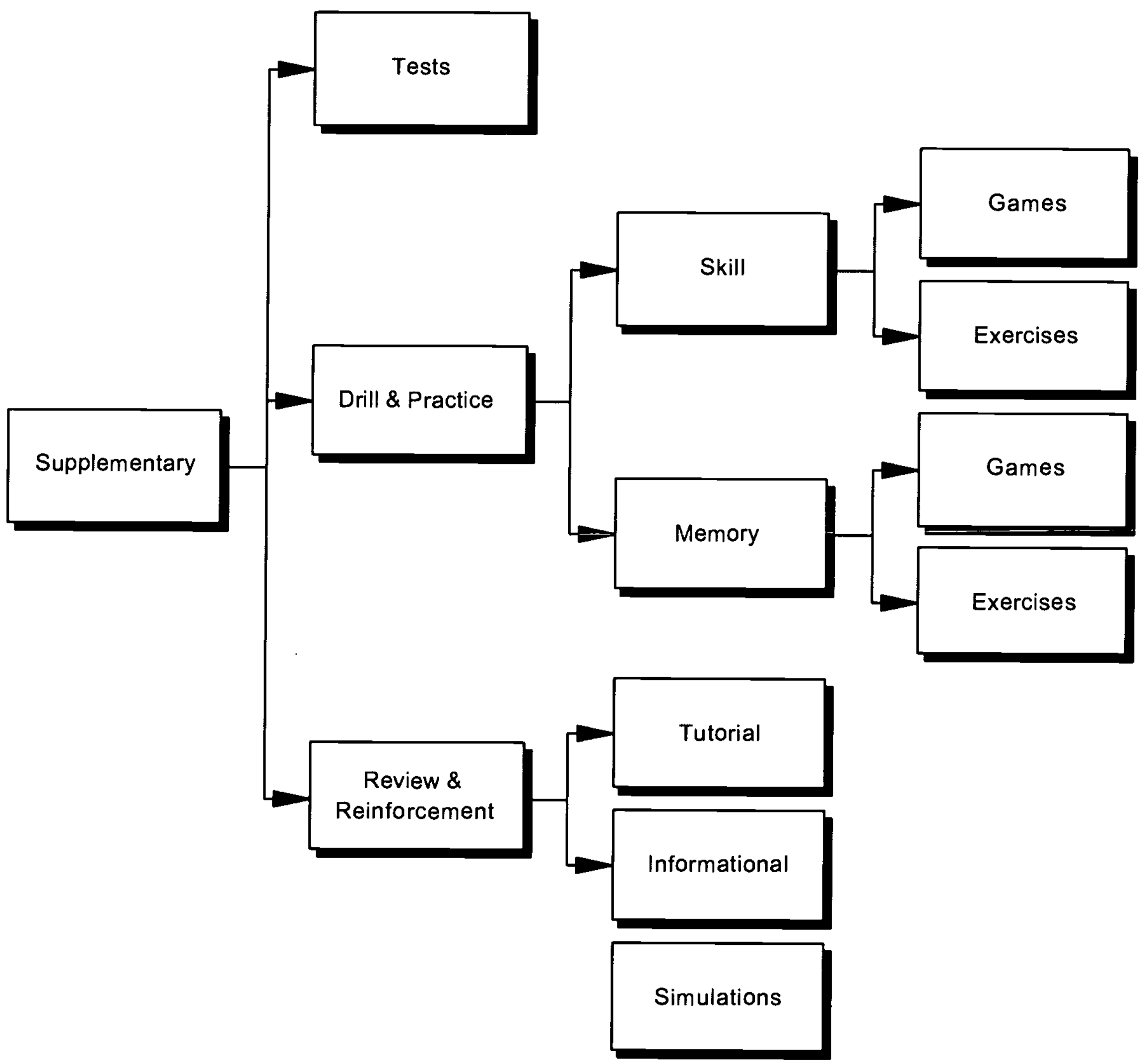
Supplementary Software

Supplementary software is typically a functional equivalent of an instructional activity done without a computer. This is probably the most commonly available type of software. It is often the type of software instructors use first, because its purpose is easily understood and it requires little change in teaching practices: all that is needed is simply to replace a non-computer activity with a computer one. This type of software thus is easy to use and usually requires the least training to use effectively.

The limitation is that software use of this type rarely leads to large gains in learning outcomes, because there is little or no net new addition of content to the curriculum. However, gains can result if the learning activity in the software is more effective than the non-computer one it replaces. For example, many successful PLATO programs use PLATO tutorials for review, reinforcement and remediation in conjunction with classroom instruction.

Risks of introducing the new technology for supplementary use are small. If the software is unsatisfactory for any reason, the instructor usually can quickly revert to the "old" (non-computer) methods. If the budget is too small to allow purchase of an entire course's software, then whatever funds are available can be used for small-scale supplementary software.

Supplementary applications most often require a learner:computer ratio of 1:1. However, some games are designed to allow use by a small number of learners (in a ratio of 2:1 to 4:1 or so).



Kinds of supplementary software include:

- *Tests* which simply mimic what can be done without a computer. Advantages of such systems include automatic administration, scoring and record-keeping, but the test design is no different from paper-and-pencil formats. These are often used as a time saver for instructors, and as practice tests to prepare for a high-stakes test such as a state competency test or college admissions tests.

- *Drill and Practice Skill Games.* The goal of any type of drill and practice is to build fluency (rapid, error-free performance) and retention, while reducing the mental effort needed to do the task. Drill and practice skill games often use arcade-style formats to add interest value. They often emphasize tasks such as quick solving of an addition problem in order to shoot down an alien invader, win a race, navigate a maze, etc. Many "edutainment" titles fall in this category.

- *Drill and Practice Skill Exercises* are essentially on-line workbooks which emphasize tasks such as solving textbook-style math word problems, reading stories (perhaps with audio backup and on-line textbook-style comprehension questions), writing assignments, etc. Lessons of these types are a part of most PLATO tutorial modules.

- *Drill and Practice Memory Games* again often use arcade-style formats to add interest value, but the instructional task involves factual recall. Examples include "mystery" puzzles in which access to clues requires remembering historical or geographical facts, or a trip through space in which progress is controlled by remembering the names of the planets, an electronic spelling bee tournament, etc. Again, this is a common "edutainment" category.

- *Drill and Practice Memory Exercises* often serve as electronic alternatives to conventional recall drills with flash cards, mnemonics, etc. An example is the *PLATO Vocabulary Builder*, which incorporates an instructionally sound strategy for memorizing words through a combination of definitions, context sentences, roots, prefixes and suffixes, mnemonic cues, and audio pronunciation.

- *Review and Reinforcement Tutorials* are on-line lessons with explanations and frequent thought-provoking questions and feedback. In supplementary use, they repeat what was already taught in other modes (such as through a combination of classroom explanations and textbook reading assignments). The tutorials can be used immediately after the classroom lesson, or for review just before a test. Examples include the many PLATO tutorial lessons in math, language arts, science, and workplace skills.

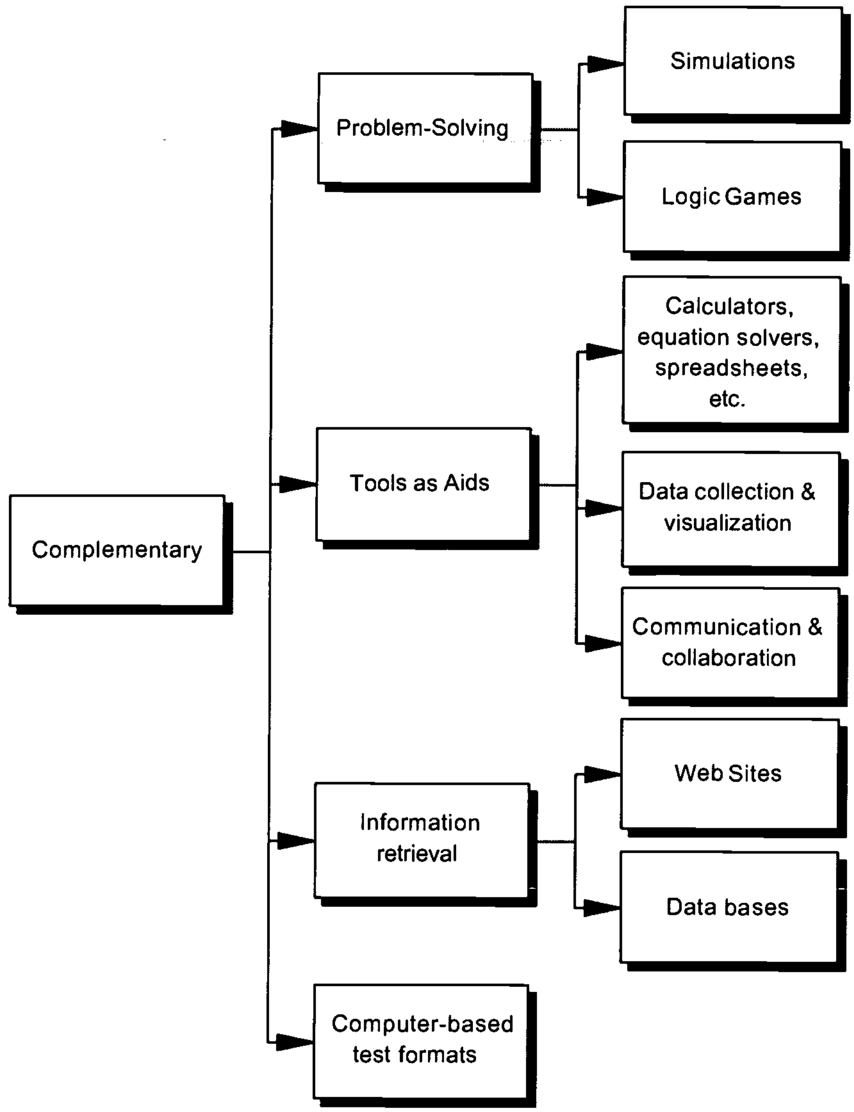
- *Review and Reinforcement Informational* software are on-line text, graphic, or multimedia presentations. They do not have the interactive questions and feedback found in tutorial software, and thus provide little or no practice. These are commonly found on the World-Wide Web, at hundreds of thousands of Web sites. They are often used as an alternative

to comparable reading in books, and are assigned (or found) after initial teaching of a topic in class, to provide alternative explanations or additional details. They also are common in distance education, where they may assume a primary role (see below).

Complementary Software

Complementary software is used to introduce into the curriculum a learning activity which could not be done by alternative means (with acceptable time, cost and risk). Complementary software often does not replace any conventional teaching, but often augments it. New learning outcomes are thus directly related to use of the software: the more such activities there are, the more new learning outcomes result. Substantial gains in learning are possible with complementary software if it is used extensively in a curriculum. Advocates of *constructivist* teaching methods often support complementary software uses which stress inductive approaches to teaching, with the instructor in the role of "guide on the side."

However, time to do the complementary activities can become a problem in large-scale use, and instructors may feel that addition of the new learning activities competes for time with the established curriculum. Instructors may also be concerned that complementary methods by themselves are inefficient and inconsistent in helping learners acquire the "foundation" or "scaffolding" of basic knowledge and skills needed to solve problems. As a generality, complementary software often requires intensive instructor training, because the software itself may be complex, and its effective use may require new teaching techniques.



Kinds of complementary software include:

- *Problem-Solving Simulations*. These are representations of a real system (such as a cell, ant colony, urban economy, village, molecule, airplane, etc.) which behave as the real system would, as the learner modifies specified variables. Often, the simulations are designed to modify space or time to make visible phenomena and causal principles which are not visible in reality. For instructional purposes, it's important for the learner to be focussed on solving a problem, so "play" with the simulation is goal-directed. Many simulations leave this task to the instructor, but some have a problem-solving dialog built into the system. Examples are built into the lessons of PLATO's *Applied Physical Science* course. In one lesson, learners can boil water on a simulated stove under conditions they vary, in order to see the relationship between heat flow, time and temperature.

- *Problem-Solving Logic Games* have the advantages of a simulation, but the software is structured according to the logic of a specific problem. Simulations may also be included, although often on small scale. An example is the PLATO *Math Problem Solving* series, in which each authentic problem is presented using an "Adventure Game" structure in which learners must "ask" co-workers for information, "explore" resources, and use tools. The logical structure of the problem is built around the mathematical reasoning tasks inherent in the problem. An "intelligent coach" "observes" the learner's actions and engages in a dialog about the learner's problem-solving strategy.

- *Tools* can be used to automate low-level parts of a classroom learning task, thus making it possible for learners to concentrate on higher-order thinking tasks. For example, calculators, spreadsheets, and equation solvers can automate the mechanics of computation, just as they do in business settings. With skilled instructor involvement, learners can focus their attention on the logic of the problem without getting "lost in the weeds" of computing the answer. Tools of these types are built into PLATO's *Math Problem Solving* curricula.
  Similarly, the right tools can help learners quickly and easily gather and represent data, allowing attention to focus on higher-order tasks of pattern abstraction, trend prediction, and the like—with the direction of a skilled instructor. An example might be the graph plotters built into PLATO's *Math Problem Solving.*
  Tools for communication can place learners in contact with one another and with learners and settings beyond their immediate environment. In the hands of a skilled instructor, such experiences can add authenticity to learning and deepen understanding. An example is the chat room and e-mail system built into PLATO, or a collaborative word processor such as *Daedalus*.
  What these tools have in common is that they are open-ended: they impose little structure on how they will be used. They automate only low-level tasks, not high-level thinking and problem-solving skills. They typically do not have learning tasks built in, and cannot provide feedback on problem-solving strategy or tactics. Thus, it is up to the instructor and the learners to use the tools well, as points of leverage to better deal with the logic of the problem at hand. [1]

- *Information Retrieval* systems automate the tasks of factual recall. In a sense, they do for memorization what calculators do for computation. Examples include on-line data bases of factual information, such as dictionaries, glossaries and encyclopaedias built into PLATO. Perhaps the most familiar kind of information retrieval is found on the World Wide Web, in the millions of Web sites available.
  The vast majority of these Web sites are informational, not instructional: they do not include opportunities for learners to frequently respond with

[1] A good reference for instructional use of tools is Morrison,G., Lowther, D. and DeMeulle, L. (1999). *Integrating Computer Technology into the Classroom.* Upper Saddle River, NJ: Simon & Schuster.

meaningful thinking, and to receive feedback on their responses. Instead, the purpose of a typical Web site is only to disseminate information. Web sites typically do not have objectives to specify learning outcomes, nor do they have any way to measure if the learning outcomes have been achieved. Instead, like tools, they make relatively few assumptions about how the information they contain will be used or who the users will be (though they must make some to determine organization and style). It is up to a skilled instructor to guide learners toward effective use of the information, and to provide an instructional context of problems, practice and feedback needed to make a full instructional experience.

- *Computer-Based Testing Formats* do testing in ways which are not possible in paper-and-pencil formats. For example, most PLATO tests improve test security by randomly selecting test questions from a bank of items, so no two learners see the same test. Scoring also is automatic. This makes on-demand testing feasible.
  It's also possible to improve the precision of short tests by having the computer decide what to ask next, based on the learner's pattern of answers on previous questions. This is a feature of PLATO's *FASTRACK* placement testing system.

Complementary applications often can be used in small groups, with a learner:computer ratio of up to 4:1 or so (an obvious exception is tests, which of course must have a ratio of 1:1). As with any collaborative use, however, the learners must develop the teamwork skills needed to involve all group members in the task at hand.

Primary Software

In primary applications, some major part of the initial teaching is assigned to the computer. This allows the instructor to become a "guide on the side" rather than a "sage on the stage." Primary applications can be used to individualize heavily, by developing a unique learning path for each learner, which the learner then studies at his or her own pace. They can be used for the whole class, or for any "special needs" group such as accelerated/remedial study, advanced study, English as a Second Language, Learning Disability, etc. These applications may use a *mastery learning* model. Primary applications also lend themselves well to distance learning.

If individualization is not an issue, everyone in a class or group can use the software (with minimal individualization) for a first introduction to the content, which is then followed by non-computer whole-group learning activities.

Complementary and Primary instructional strategies can be combined in a problem-centered/collaborative approach. For example, an algebra instructor can use PLATO in this way:

- Each unit begins with individualized remedial study of prerequisite skills for those who need it, using tutorial modules.
- Then the new ideas for the unit are introduced in a collaborative learning strategy using problems from the *Math Problem Solving* series or from other sources.

- After encountering the needed math concepts in the context of authentic problem-solving, the learners then study the concepts and skills in the corresponding tutorials.
- Whole-class sessions focus on non-computer teaching strategies such as use of manipulatives to teach the same concepts.
- The learners return to the problems to solve them collaboratively, using their newly-acquired knowledge and skills.
- As a concluding activity, the instructor poses an additional problem of the same type, but without the scaffolding and coaching provided by *Math Problem Solving*. Researching the problem may require use of additional Web informational resources.

Primary applications typically involve tutorial and/or problem-centered software. Because of its lack of structure, tool software cannot serve in a primary role, though it may be a useful complement to a primary strategy executed with other software. Drill and practice, edutainment, and other supplementary software types also have inadequate instruction to work well in a primary role. In distance education applications, it's common to use on-line textbooks, video programs, or other explanatory resources, and "wrap around" exercises and dialogs with the instructor and other learners. This approach emulates a classroom model, but usually is less effective than the intense high-quality interactivity of a well-designed tutorial.

A well-documented advantage of tutorial software in primary applications is that it is up to 40% more efficient than conventional classroom lecture/discussion methods: learners who can work ahead quickly do so, while those who need more time can have it, and the class-wide average time goes down even though the range of times needed is quite large.

Primary and complementary applications can be quite complementary in a curriculum. The primary strategy can be effective for teaching the basic knowledge and skills of a subject, while the complementary strategies can be effective for helping learners integrate and synthesize their knowledge to develop higher-order thinking skills and deep understanding. Furthermore, the efficiency of primary strategies can help free up classroom time for complementary applications.

A common misconception is that primary methods are "instructor replacements." While it is true that primary strategies often include self-instructional use, our PLATO experience is consistent with the research that active involvement of a skilled instructor in the "guide on the side" role can double the learning outcomes achieved. Skilled instructors can use primary instructional strategies as a point of leverage to change their role in the classroom, to individualize, and to extend learning outside the classroom, as in school-to-home applications.

Primary applications vary in their requirements for learner:computer ratio. Tutorials usually are designed for 1:1 or 2:1 learner:computer ratios. Problem-solving activities such as PLATO's *Math Problem Solving* are often designed for collaborative groups of up to 4:1 in size, as well as 1:1 individual use.

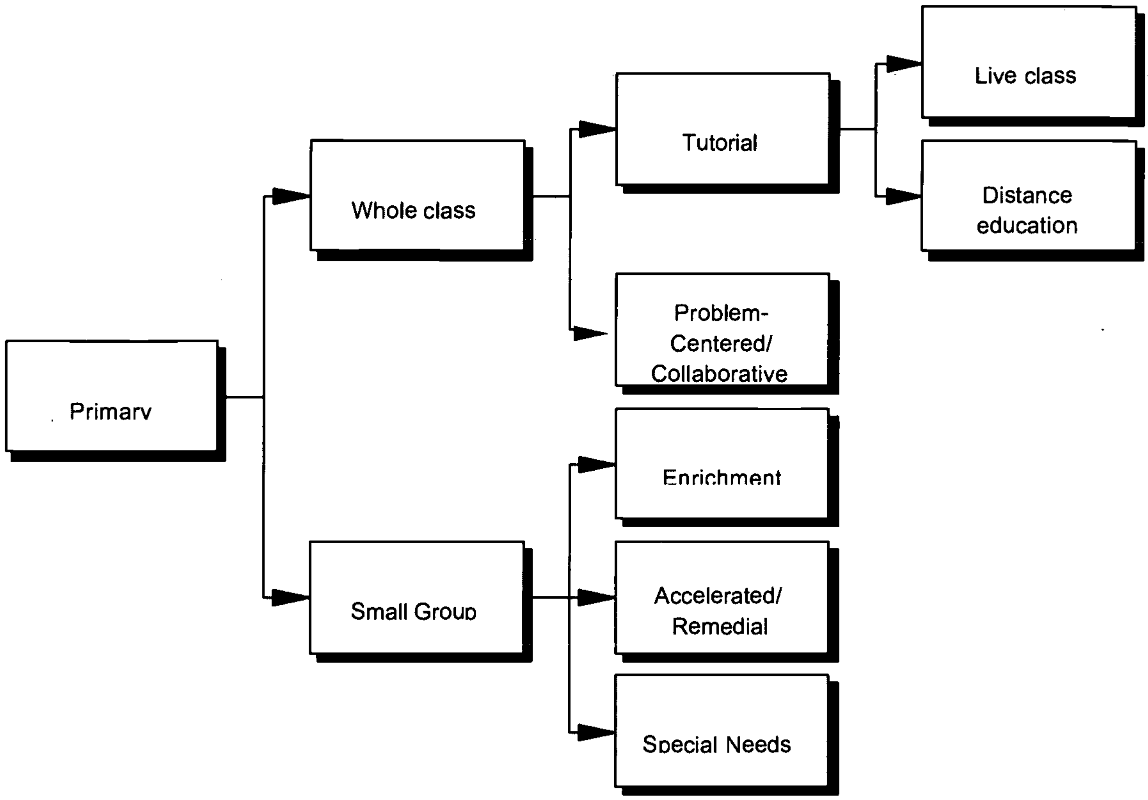
Scheduling of computer time can be a major issue for individualization. Our experience with PLATO is consistent with research on Mastery Learning: in a school population, it's not uncommon to see that what one learner can complete in 1 hour can take another learner 6 hours to complete. This means that when you individualize, you'll need to find

a way to provide considerable extra computer access for those learners who need it, perhaps by providing extra computers in the media center, extending operating hours, or assigning learners on-line homework (for example, via PLATO on the Internet).

Primary applications lend themselves not only to in-school use, but also to distance education programs serving populations such as homebound learners, home schoolers, rural/remote learners, adults, etc. In addition, special populations who cannot attend school, such as adjudicated youth, teenage mothers, etc. often can use primary software. Programs without instructional staff for each subject also use primary applications effectively. For example, these include programs in community-based organizations, adult learning programs, and workplace learning programs, as well as "after school" assistance programs.

Primary applications, if they are large enough in scope, can lead to major gains in learning. However, they require the instructor to assume what may be a new role ("guide on the side"), so professional development is a "must." In addition, some schools find it difficult to provide the flexible access to computers this model requires. For some schools, the requirements of the mastery learning model are administratively incompatible with policies for grading and advancement.

The diagram on the next page shows the various types of primary use.


Primary
Whole class
Small Group
Tutorial
Problem-Centered/ Collaborative
Enrichment
Accelerated/ Remedial
Special Needs
Live class
Distance education

Model #1: Review/Reinforcement

GOAL

The goal of the supplementary instructional model is to reinforce the knowledge and skills of the learner.

Primary instruction is assumed to be done in the classroom, without use of PLATO. PLATO lessons are assigned (often as seat work or out-of-class work) before a given classroom lesson to review prerequisite concepts, or after a classroom lesson to provide additional reinforcement, review and practice of the topics taught in class. The PLATO work can occur immediately following the classroom instruction, or after a delay (such as for end-of-unit review or review before a unit test, final exam, or competency test).

This model makes it easy to integrate PLATO instruction with other ways of teaching the same content, so it is popular among instructors who believe it is important to teach the same concept in a variety of ways to accommodate various learning styles. It also is used in supplementary study programs such as after school programs or home assistance. It also is used for test preparation programs for adults or young adults, in situations where mastery model instruction is not feasible (see the *skill development model* for further discussion of mastery model instruction).

This model has the advantage of requiring only a basic familiarity with PLATO's capabilities. Thus, it is often used by instructors who are new to PLATO and not fully trained in its use.

However, net improvements in learning resulting specifically from use of PLATO are usually difficult to predict or evaluate. There are many examples of successful PLATO programs which use this model, especially where remediation is important. However, overall improvements in program effectiveness may be relatively small, in comparison to the other models.

PLACEMENT

This model assumes that all learners are working on the same topics at the same time, or that all the learners are preparing for the same test to be administered at once. Either way, the assigned portions of the PLATO curricula are the same for all learners. It's especially important that PLATO assignments must be closely aligned and synchronized with each instructor's actual teaching schedule, so that assignments to review prerequisites are done just before the classroom lesson, and assignments to reinforce and practice lessons studied in class are made just after each classroom lesson. Learners reviewing in preparation for a large test should study as close to the test date as is feasible (without "cramming"), and should use a learning path based on an alignment to the curriculum standards which correspond to the test.

Since PLATO assignments are determined entirely by the structure of the course syllabus or test, there probably is no need to do placement testing unless the instructor wishes to use PLATO specifically to "fill in the gaps" for particular learners who lack prerequisites. In this case, refer to the *Skill Development* instructional model for placement options.

LEARNER ROLE

Learners' progress is self-paced. We recommend that learners be encouraged to try module mastery tests once (and only once) before studying a module they think they may already have mastered. Then learners who pass the mastery test can skip ahead (see below).

The learner:computer ratio is 1:1. All study is private, though peer tutoring (in a 2:1 configuration) is often useful.

To help sustain motivation, a good strategy is to cluster learners together into "study groups." It's probably more important for the members of the group to share common goals (such as doing well on a major test), than it is for them to be at a similar ability level. Off-line peer teaching is an additional benefit of study groups. However, study groups may not work among learners who have negative group interaction histories and poor mutual trust.

Some instructors also help sustain motivation by assigning a percentage of the learner's grade to timely mastery of assigned PLATO modules.

INSTRUCTOR ROLE and PROGRAM STRUCTURE

The instructor's role in the classroom instruction which PLATO supports is not affected. All PLATO work is done independent of large-group teaching, in seat work periods, or in times such as study periods or after-school study programs, or at home via *PLATO on the Internet.*

The instructor should be available during or shortly after the PLATO work sessions to help clarify any questions remaining. The tutoring can be done "live," or in distance education settings via telephone or even e-mail and chat groups. As mentioned above, it is often helpful to organize small study groups of learners with a common goal, to facilitate peer tutoring during and after PLATO work. This recommendation is equally applicable all settings and ages of learners if positive group interaction patterns can be established. It may not apply for groups with low trust, as is found in some remedial and advanced study settings.

To sustain participation, learners must see a clear link between what they are studying and a meaningful personal goal such as graduation, GED equivalency, catching up to peers, work readiness, etc. Instructors should work individually with each learner to establish personal goals for the PLATO work.

It's also important for instructors to reinforce the message that work on PLATO is independent and empowering. It avoids the negative experiences of the classroom, and is a dignified, personal way to learn. Encourage learners to take responsibility for their own learning; PLATO is the tool which allows them to do this.

Demonstrate your own enthusiasm for the content being studied, and be a positive model for good learning practice.

In work environments, long-term participation will be best if learners are paid for their training time.

PLATO can be set to permit progress to the next module whether or not the learner has passed the previous module's mastery test. This probably makes sense in most settings. However, learners often overestimate how well they understand something they have studied. Therefore, we recommend that learners be strongly encouraged or required to take the mastery tests (once) for all assigned modules (even if they don't feel they need the tutorials). Instructors who turn off the requirement to master before progressing usually believe their learners can make appropriate judgements about what to study and how long. They often urge learners to use the tests on their own to guide their progress, while using their judgement to skip irrelevant content. On the other hand, instructors who turn this feature on are usually concerned that learners will "cheat" by skipping ahead without taking mastery tests first.

If use of the mastery tests is considered too threatening or "childish," the instructor may assign only the tutorial and/or practice lessons within each module, and may encourage learners to skip modules they feel they fully understand. However, instructors who use this option should expect less consistent learning from the use of PLATO, even by well-motivated learners.

Instructors should help learners develop realistic expectations about their experience. Learning via PLATO is often more efficient than learning in a conventional classroom, but that doesn't make it a "quick fix." PLATO will allow the learners to move quickly through what they already know, if the learners take and pass the mastery test for each assigned module, even if they feel they don't need the tutorial or practice lessons, or if a non-PLATO unit or final exam is to follow.

Best results are obtained when the instructor monitors progress and adjusts the instructional prescription as needed. Particular "red flags" are:

- More than two hours spent on a module
- More than 2-3 tries on the mastery test
- Only 1 try on a tutorial, accompanied by more than an equal number of tries on the mastery test
- Abnormally low times spent on tutorials and application lessons, accompanied by a large number of tries on the corresponding mastery tests.
- Learner questions or non-verbal signs of confusion or frustration; statements that it's "too hard," "too easy" or "boring."
- Abnormally slow or fast progress

Instructors noticing these "red flags" should intervene and "troubleshoot" the problem. Experience has shown likely problems are often:

- Too many or too few prerequisite skills assumed by the classroom lesson plan and supplemental PLATO assignments, leading to assignments which are too far below or above what the learners are ready to learn.
- Insufficient, or too infrequent, time on PLATO.
- Use of a path based on the wrong alignment for the purpose, resulting in prescriptions to study modules which do not correspond to the current classroom lesson or its prerequisites.
- Insufficient connection for learners between their own personal goals and study on PLATO.
- Poor learner control decisions, such as skipping tutorials and re-taking a mastery test repeatedly to try to "beat the system" (Pathways can be set to limit the number of tries on a mastery test).
- Inadequate skills in keyboarding or mouse skills, or "computer anxiety."
- Inadequate skills in reading or English.
- "Hands off" attitude, or absent, instructor, who inadvertently passes this view on to the learners.
- Motivational problems unrelated to PLATO, such as overconfidence or underconfidence, excessive anxiety, fatigue or stress, negative group/peer pressure, etc.
- Undiagnosed or untreated learning disabilities.

In this model, there is no requirement for PLATO courseware to provide a complete, self-sufficient solution for any curriculum topic. However, it's especially true in language arts courses, where whole-skill practice of reading (especially out loud) and

free-form writing are an important part of the curriculum but beyond what is possible on computers with current technology.[2]

Instructors in this environment need to be fully familiar with the PLATO courses in use, and any program tests or curriculum standards.

For test preparation review, use a custom curriculum path which is based on an alignment of PLATO to the standards and tests you use. We recommend use of the default path which includes the whole curriculum only if your program does not operate with any pre-defined standards or non-PLATO tests.

For supplemental use in support of classroom instruction, prepare a curriculum path which corresponds exactly in objective and sequence to the classroom curriculum and assigns PLATO modules which review prerequisites or reinforce the current classroom lesson. Instructors may wish to assign only the tutorial and practice lesson, the practice lesson alone, the tutorial alone, or the entire module including its mastery test.

RESOURCE MANAGEMENT

To optimize the opportunity for learner success you must take into account two variables:

- the length of time of each session and ,
- the number of sessions per week, per subject.

For this model, we recommend:

- The learner:computer ratio is 1:1 for the time each learner is on PLATO.
- There is no minimum requirement for amount of time per week per learner spent on PLATO. Figure an average of 30-45 minutes per module (if tutorial, practice and mastery test are all assigned), and multiply by the number of modules to be assigned. When scheduling learners to work on PLATO, a useful "rule of thumb" for adults and young adults to avoid fatigue is not to allow more than 3-5 hours per subject per week on the computer.
- If a learner spends more than one hour attempting to understand and master a module objective, the instructor should intervene with alternative sources of instruction to assist the learner.
- There is no requirement for the learners to all be in the same place at the same time, or to start or finish at the same time, as long as they stay "in synch" with corresponding classroom instruction.
- Instructor-learner contact can be done face-to-face or by any combination of telecommunications media in distance education settings.

[2] PLATO technical papers on teaching of mathematics and language arts are in development, and will contain additional discussion of teaching strategies in these curricula.

- In a 90-minute block scheduling environment, we recommend assignment of the whole block to PLATO study only for older, well-motivated learners. Many instructors prefer to divide the block in two, resulting in approximately 45 minutes per learner on PLATO. However, a "lab" setting where learners are encouraged to do peer tutoring and otherwise vary their tasks can easily involve 90 minutes on the computer without fatigue.
- Work stations may be in a computer lab or in a work cluster in the classroom; or, learners may work on their own from a supervised location such as a media or training room, or a quiet work room or at home.
- In work environments, employees should be scheduled to work on PLATO during their shift, or before it if possible. Make sure there are no interruptions during study.
- In all environments, providing PLATO access for the whole family (a family literacy model) will often help sustain participation. There is no reason to ever turn off the PLATO system: it can be available 24 hours per day, 7 days per week, on site from work stations or accessed from a home computer via the Internet or direct dial-up connection.

ASSESSMENT OF LEARNERS

Achievement is measured by the non-PLATO tests already in use.

If your program requires use of grades for homework or out-of-class work, and if you require use of module mastery tests, then you can base the grades on number of modules mastered, attainment of mastery goals, or mastery of intermediate goals (milestones) toward a larger goal.

If you do not require mastery testing, then you may want to simply check that the "completed" flag is set for each assigned lesson.

Credit hour equivalence is not usually an issue in this model.

Model #2: Enrichment/Exploration

GOAL

The goal of this instructional model is to enrich the knowledge and skills of the learner through use of any relevant PLATO curriculum.

Primary instruction is assumed to be done in the classroom, without use of PLATO. PLATO lessons and other on- and off-line materials are assigned (often as seat work or out-of-class work) by the instructor or selected by the learner through exploration. Study is usually after a classroom lesson, and is used to provide additional knowledge and skills for learners who want more depth, background, or advanced work in a subject. The computer work can occur immediately following the relevant classroom instruction, or in support of an independent research or learning project.

Enrichment also is used in independent study programs such as after school programs, extracurricular "clubs," or home assistance. It also is used for family/home learning programs, in situations where mastery model instruction is not feasible (see the *skill development system model* for further discussion of mastery model instruction). It also is used for able learners who need to take a course using an "independent study" strategy, because of specialized topic interests, for advanced placement, inability to attend school, or simply to resolve a scheduling conflict that prevents access to a conventional class.

This model has the advantage of requiring relatively little instructor training. As a result, this model is often used by instructors who are new to PLATO and not fully trained in its use. Another advantage is that this model is suitable for large learner:computer ratios (as is common when computers are placed in classrooms), .since there is no requirement for a large number of learners to be using computers at the same time, and study may be in pairs.

However, net improvements in learning resulting specifically from use of PLATO are usually difficult to predict or evaluate. Learning gains can be large if PLATO use is extensive, and study is of content not otherwise taught.

PLACEMENT

This model does not require a close linkage between what is studied in the classroom and what is studied on the computer, except to be sure that prerequisites have been taught before any given on-line activity is started.

Since learners are working independently or in small groups, there is no requirement for portions of the PLATO curricula assigned to be the same for all learners. Learners may explore topics of interest on their own by self-selecting the PLATO modules or other learning activities they want to study, based on their interests. Or, the instructor may assign predetermined paths which are keyed to special topics, projects, or needs for enrichment. Teachers using this model often look for the "teachable moment" (zone of proximal development), when individual learners are ready to learn about a new topic.

In this model, PLATO assignments are determined entirely by the learner's interests and the structure of the course syllabus or test, so there probably is no need to do placement testing unless the instructor wishes to make sure a learner has mastered the prerequisite skills for a given path. If this is the case, refer to the *Skill Development System* model (#4, below) for placement options.

LEARNER ROLE

Learners' progress is self-paced. We recommend that learners be encouraged to try module mastery tests once (and only once) before studying a module they think they may already have mastered, and to skip ahead if they pass the mastery test (see below).

The learner:computer ratio is 1:1 or 2:1. All study is private or in pairs. Study groups at ratios up to 5:1 have been reported, but some research suggests there is a significant fall-off of learning when more than a pair of learners are working together. Of course, mastery tests should be administered 1:1 in a secure environment, if the results are important.

Participants in the study groups can be peers in the same class or learners with a common interest or goal (such as a club or special activity or need). In a family literacy setting, the learners can be the whole family, working together (on a home computer via PLATO on the Internet, or in a non-school lab environment such as a library/media center or community development center).

Learners should be encouraged to explore the learning opportunities of the system, and to follow their own interests. In general, research has shown that modest violations of logical sequence of content development don't impede understanding, as long as the learners eventually study all the "pieces."

The pattern of PLATO usage is likely to be episodic, rather than sustained over a long period of time. The emphasis is on "on-demand" or "just in time" learning, so learners tend to select topics to study only when a question comes up in the course of another activity, such as a project. If motivation is high, and the learner (or instructor) has selected appropriate instruction, then learners can progress through curricula very rapidly.

To help sustain motivation, a good strategy is to cluster learners together into "study groups." It's probably more important for the members of the group to share common goals, than it is for them to be at a similar ability level. Off-line peer teaching is an additional benefit. However, study groups may not work among learners who have negative group interaction histories and poor mutual trust.

INSTRUCTOR ROLE and PROGRAM STRUCTURE

Using the *PLATO Pathways* management system, the instructor may construct specialized curriculum strands (paths) by combining PLATO lessons, web sites, other instructional or informational software, and tools, together with notes to the learner with project assignments or discussion questions. One way to do this is to create topical "exploration projects" which start by posing an interesting question or dilemma, include a variety of resources of relevance (including PLATO lessons, web sites, books, tours, interviews, etc.), and conclude with an assignment to prepare a synthesis such as a report, web site or peer learning activity.

The instructor's role in the classroom instruction which PLATO supports is not affected. All PLATO work is done independent of large-group teaching, in seat work periods, or in times such as study periods or after-school study programs, or at home via PLATO on the Internet.

The instructor should be available during or shortly after the computer work sessions to help clarify any questions remaining. The tutoring can be done "live," or in distance education settings via telephone or even e-mail and chat group. As mentioned above, it is often helpful to organize small study groups of learners with a common goal, to facilitate peer tutoring during and after computer work. This recommendation is equally applicable to all settings and ages of learners when positive group interaction patterns can be established. It is particularly valuable in family literacy settings.

To sustain participation, learners must see a clear link between what they are studying and a meaningful personal goal such as personal curiosity, personal advancement, work readiness, etc. Instructors should work individually with each learner to establish personal goals for the PLATO work.

It's also important for instructors to reinforce the message that work on PLATO is independent and empowering. It avoids the negative group experiences of the classroom, and is a dignified, personal way to learn. Encourage learners to take responsibility for their own learning; PLATO is the tool which allows them to do this.

Demonstrate your own enthusiasm for the content being studied, and be a positive model for good learning practice.

In work environments, long-term participation will be best if learners are paid for their training time and/or training is done during normal work hours.

PLATO *Pathways* can be set to permit progress to the next module whether or not the learner has passed the previous module's mastery test. In this model, this probably makes sense in most settings. However, learners often overestimate how well they understand something they have studied. Therefore, we recommend that learners be strongly encouraged or required to take the mastery tests (once) for all assigned modules (even if they don't feel they need the tutorials). Instructors who turn off the requirement to master before progressing usually believe their learners can make appropriate judgements about what to study and how long, and will use tests on their own to guide their progress while using their judgement to skip irrelevant content. On the other hand, instructors who require mastery of each module are usually concerned that learners will "cheat" by skipping ahead without taking mastery tests first.

If use of the mastery tests is considered too threatening or "childish," the instructor may assign only the tutorial and/or practice lessons within each module, and may encourage learners to skip modules they feel they fully understand. However, instructors who use this option should expect less consistent learning, even by well-motivated learners.

Instructors should help learners develop realistic expectations about their experience. Learning via PLATO is often more efficient than learning in a conventional classroom, but that doesn't make it a "quick fix." PLATO will allow the learners to move quickly through what they already know, if the learners take and pass the mastery test for each assigned module even if they feel they don't need the tutorial or practice lessons, or if a report or project is the ultimate goal. Alternatively, if PLATO Pathways is set to allow full learner control, learners can simply select only the modules and activities of interest to them.

Best results are obtained when the instructor monitors progress and adjusts the instructional prescription as needed. Particular "red flags" are:

- More than two hours spent on a module
- More than two or three tries on the mastery test
- Only 1 try on a tutorial, accompanied by more than an equal number of tries on the mastery test
- Disproportionately low time spent on tutorials and practice, with a high number of tries on mastery tests
- Learner questions or non-verbal signs of confusion or frustration; statements that it's "too hard," "too easy" or "boring."
- Abnormally slow or fast progress

Instructors noticing these "red flags" should intervene and "troubleshoot" the problem. Experience has shown likely problems are often:

- Too many or too few prerequisite skills assumed by the PLATO assignments.

- Insufficient, or too infrequent, time on PLATO.
- Insufficient variety of learning activities.
- Use of a path based on the wrong alignment for the purpose, resulting in prescriptions to study modules which do not correspond to the current topic or learner interests.
- Insufficient connection for learners between their own personal goals and study on PLATO.
- Poor learner control decisions, such as skipping tutorials and re-taking a mastery test repeatedly to try to "beat the system" (Pathways can be set to limit the number of tries on a mastery test).
- Inadequate skills in keyboarding or mouse skill, or "computer anxiety."
- Overconfidence or underconfidence
- Inadequate skills in reading or English
- Lack of readiness to learn, due to unresolved personal or family needs.

In this model, there is no requirement for PLATO courseware to provide a complete, self-sufficient solution for any curriculum topic. However, it's especially true in language arts courses, where whole-skill practice of reading (especially out loud) and free-form writing are an important part of the curriculum but beyond what is possible with current technology.

Instructors in this environment need to be fully familiar with the PLATO courses in use, and with the non-PLATO web sites or software included in the assigned paths.

RESOURCE MANAGEMENT

To optimize the opportunity for learner success one must take into account two variables:

- the length of time of each session and ,
- the number of sessions per week, per subject.

This model is popular for classrooms equipped with 5 computers or so which serve 25 or more learners. For this model, we recommend:

The learner:computer ratio is 1:1 or 2:1 for the time each learner is on PLATO tutorials. PLATO problem-solving activities and Tool-using activities such as Web surfing, preparation of web sites or presentations, or e-mail interviews with experts can sometimes be effectively done with ratios up to 4:1 or so.

There is no minimum requirement for amount of time per week per learner spent on PLATO. Figure an average of 30-45 minutes per module (if tutorial, practice and

mastery test are all assigned), and multiply by the number of modules to be assigned or selected. Add in an estimate of time required for additional Web site exploration or other non-PLATO activities. When scheduling learners to work on the computer, a useful "rule of thumb" for adults and young adults to avoid fatigue is not to allow more than 3-5 hours per subject per week on the computer. However, highly motivated learners have successfully spent upwards of 20 hours per week on the computer, if there is sufficient variety in the computer activities.

Thirty minutes of study in a tutorial module is considered average in many courses. If a learner spends more than one hour attempting to understand and master a module objective, the instructor should intervene with alternative sources of instruction to assist the learner.

There is no requirement for the learners to all be in the same place at the same time, or to start or finish at the same time. Self-pacing is desirable.

Instructor-learner contact can be done face-to-face or, in distance learning settings, by any combination of telecommunications media, either synchronous or asynchronous.

Peer tutoring is a useful addition to this model, so it's probably wise to schedule clusters of peers to work at the same time at a computer cluster.

In a 90-minute block scheduling environment, we recommend assignment of the whole block to PLATO study (or other computer use) only for older, well-motivated learners. However, a setting where learners are encouraged to do peer tutoring and otherwise vary their tasks can easily involve 90 minutes on the computer without fatigue. Additional variety can be added through assignments to play with simulations, surf the Web, or use appropriate software tools.

Work stations may be in a computer lab or in a work cluster in the classroom; or, learners may work on their own from a supervised location such as a media center or training room, or an quiet work room or at home.

In work environments, employees should be scheduled to work on PLATO during their shift, or before it if possible. Make sure there are no interruptions during study.

In all environments, providing PLATO access for the whole family (a family literacy model) will often help sustain participation. There is no reason to ever turn off the PLATO system: it can be available 24 hours per day, 7 days per week, on site from work stations or accessed from a home computer. Families at home also can use PLATO on the Internet.

ASSESSMENT OF LEARNERS

Achievement is measured by assessment of assigned reports, projects, etc.

If your program requires grades for homework or out-of-class work, and if you require use of mastery tests, you can base the grades on number of modules mastered, attainment of mastery goals, or mastery of intermediate goals (milestones) toward a larger goal.

If you do not require mastery testing, then you may want to simply check that the "completed" flag is set for each assigned lesson. If you use tests in this way, then peer tutoring is not feasible because of the requirement for test security.

Model #3: Problem-Centered

GOAL

The goal of this instructional model is to make problem-solving the central strand of the curriculum. Development of knowledge and skills is done in the context of problem-solving, as a pre- or co-requisite. The intended learning outcomes include deeper understanding, greater transfer to non-school tasks, development of learning skills, and greater motivation.

At the center of each unit is a problem-solving activity which can be a PLATO Problem Solving Activity (PSA), or other case problems implemented on the computer or offline. Knowledge and skills development is done in the context of the problems, as a pre- or co-requisite. This establishes a context for the learning of facts, concepts and skills. Work on the problem helps learners integrate their knowledge.

Much of the teaching load of knowledge and skill development can be done by the PLATO tutorial lessons used as primary instruction in a supporting role, with additional classroom instruction done in small groups as needed for topics and specialized teaching methods not available in PLATO. Using the PLATO tutorial lessons in this way frees up instructor and class time for work on the problems, while assuring that every learner is mastering the basic concepts and skills of the curriculum. In addition, PLATO tutorials can provide "just in time" review or remediation for learners who need to strengthen their understanding of prerequisite knowledge and skill used in a problem-solving activity. A common issue in problem-based learning is how to assure that each learner brings to each problem the knowledge and skills "foundation" or "scaffolding" needed. Using PLATO tutorials in this supporting role helps make sure the "scaffolding" is there when needed, for every learner.

The computer work on the PSA's can occur in the classroom or out of class. In-class use of PSA's allows collaborative learning, which is often desirable when teaching problem-

solving. Study of the supporting PLATO tutorials modules can occur in or out of class as learners prepare for and work on the problem. Additional enrichment/exploratory study can be done out of class in support of an independent research or learning project. As an optional further generalization task, learners can then work together to construct or solve additional problems with fewer tools and less scaffolding than provided by PLATO PSA's. For example, learners might work through the PLATO PSA on planning a fishing trip's budget, then use Web resources and spreadsheet tools to plan their own trip to a favorite local recreation spot.

This model may be combined with any of the other instructional models. Use of the Skill Development Model when teaching prerequisite/corequisite knowledge and skills is often a particularly powerful option. The model may also be combined with conventional classroom teaching to cover topics not taught on the computer, or to provide additional explanations using non-computer teaching methods.

This model requires that the instructors be particularly familiar with the problem-solving activities used, including the PLATO PSA's, as well as the principles of teaching problem-solving and the techniques of collaborative learning. Instructors also need to have a good working knowledge of the relevant PLATO tutorial modules. In addition, use of portfolio assessment is often an important qualification for instructors.

The model is most often used in classrooms (especially if they are block scheduled), but can also be used in independent study programs such as distance learning settings in which learner interaction is done via e-mail and other telecommunications technologies. The model has also found use in schools which build the entire curriculum around problems or projects, such as some charter schools, career academies, and vocational schools.

This model has the advantage of being usable with large learner:computer ratios. Collaborative learning work on PLATO PSA's can often be effective with learner:computer ratios of up to 4:1 or so. Tutorial study can be effective at ratios of 1:1 or 2:1. Web surfing and tool usage can be done at ratios of 4:1 or less.

PLACEMENT

This model requires a close linkage between problem-solving activities and instruction in the knowledge and skills learners use when solving the problems. The goal is to keep learners in their "zone of proximal development" as much as possible. It's important for learners to have full mastery of prerequisite knowledge and skills so they have the resources they need to do the problem-solving. Therefore, it's important for learners to fully master the knowledge and skills they need through "just in time" remedial study as needed, and then to continue study of new knowledge and skills which are pre- or co-requisite to the problem solving. Careful placement of learners in the sequence of knowledge and skill tutorials is important to make sure the learners can fully master the assigned lessons and go on to solve the problems with the desired deep understanding and integration of knowledge. This is a strong argument for individualized study of tutorials, even if learners work together on PSA's.

The PLATO PSA's are designed to fit into the PLATO curricula at specified points. For placement in the prerequisites to any PLATO PSA, the placement testing available within PLATO is recommended. See the *Skill Development System* implementation model for a description of the available options for placement.

For problem-solving activities other than the PLATO PSA's, probably the best way to do placement is to use the PLATO Custom Assessment Tool (PCAT) system to develop placement tests to check for proficiency in prerequisite skills relevant to each core problem. Administer each test just before work begins on the problem. Then, assign work on prerequisites to learners before they begin the problem-solving activity.

For co-requisite knowledge and skill development, learners may self-select the PLATO modules or other learning activities they want to study, based on their interests. Or, the instructor may assign to all learners predetermined paths which are keyed to each problem.

Pay special attention to the reading, writing, verbal and teamwork skills of the learners. Problem-solving is inherently language-intensive, and collaborative learning involves social skills of teamwork. Project work usually involves writing skills. Intermixing abilities on a team may stimulate peer teaching; homogeneous teams are not necessary.

It's also important to make sure learners know how to use any tools which are needed to prepare projects or do research, or schedule time to learn the tools.

LEARNER ROLE

Learners' progress through tutorials is self-paced. We recommend that learners be encouraged to try module mastery tests once (and only once) before studying a module they think they may already have mastered, and to skip ahead if they pass the mastery test (see below).

The learner:computer ratio is 1:1 for the PLATO knowledge & skill tutorials. PLATO PSA's are designed to be used in small groups (i.e., at a 4:1 ratio). Research on computer-assisted problem-solving suggests that problem-oriented conversation within groups (collaborative learning) of up to 4 learners can be beneficial. However, PLATO PSA's have enough scaffolding so many learners can use them in individual study at a 1:1 ratio if desired.

Learners should be encouraged to explore the learning opportunities of the system, and to follow their own interests. In general, research has shown that modest violations of logical sequence of content development don't impede understanding, as long as the learners eventually study all the "pieces."

Additional benefits of small-group work on problems can include increased motivation, informal peer teaching, and improvement of social skills such as teamwork. It's probably more important for the members of the group to share common goals, than it is for them to be at a similar ability level. Participants in the problem-solving teams can be peers in the same class or learners with a common interest (such as a club or special activity or need). However, study groups may not work among learners who have negative group interaction histories and poor mutual trust.

INSTRUCTOR ROLE and PROGRAM STRUCTURE

In any curriculum, the instructor may use PLATO *Pathways* to construct specialized curriculum strands by starting with a problem-solving activity which is relevant to the curriculum and interesting to the learners, such as the PLATO PSA's or case problems from other sources. Then, the instructor can combine PLATO lessons on pre- and co-requisite knowledge and skills, web sites, other instructional or informational software, and add comment screens with assignments and discussion questions. The work product of the path should be a solution to the problem, a way of capturing the strategy used to solve the problem, and testing on the knowledge and skills. In many PLATO PSA's, the learner's path can be compared to an expert path and printed out for discussion, as can the learner's work products and solutions. The learner also can be required to use the Notepad to explain the rationale for each step in the problem-solving process, and these entries can be stored and printed. Mastery test results are available for each tutorial module.

Many instructors use the traditional "top-down" approach where skills are first taught, then applied. For example, in this approach to the mathematics curricula, learners first complete the prerequisite PLATO Math modules listed for that PSA in the *Math Problem Solving Curriculum Guide*. Then, having mastered the relevant foundation knowledge and skills, learners are ready to tackle the real-world applications in Math Problem Solving.

Other instructors use a constructivist "bottom-up" approach. Here, the learner attempts to solve the problem without having first studied the underlying math skills. He or she will quickly discover that, "gee, I guess I really do need to know how to multiply fractions," or solve a quadratic equation, or solve a system of bounded linear inequalities, or whatever math skills are embedded in the problem. The learner then saves his or her work on the problem, exits it, and goes to the appropriate PLATO Math course to learn the foundation skills. Finally, the learner returns to complete the Problem-Solving Activity.

In either approach, the instructor's role in the classroom instruction which PLATO supports is as a "guide on the side." Large-group teaching is rare, except for kick-off and summary/debriefing activities, or for specialized topics or instructional activities not included in the software. Computer work is done by learners working alone and in teams, in seat work periods, or in times such as study periods or after-school study programs, or at home via PLATO on the Internet.

When acting as a "guide on the side" for problem-solving, the instructor should be careful to ask questions and make comments which encourage learners to reflect on their problem-solving strategy, use their reasoning abilities, and use their understanding of the content. The instructor should be careful not to "short circuit" the problem-solving process by providing answers or hints to answers which are too strong. Suggestions should encourage peers working together to discuss their reasoning to each

other, rather than to "play" the problem mindlessly like an arcade game. Many PLATO PSA's include an intelligent Coach designed to stimulate this kind of interaction. Instructors may be able to use the Coach messages as a way of starting the discussion of high-level reasoning and understanding. In addition, many PLATO PSA's allow the learner to compare his/her path through the problem to an expert path. A debriefing discussion with a printout of the path may also be useful.

The instructor should be available during or shortly after the PLATO work sessions to help clarify any questions remaining. The tutoring can be done "live," or in distance learning settings via telephone or even e-mail. As mentioned above, it is often helpful to organize heterogeneous small problem-solving teams of learners with a common goal of solving the problem, to facilitate peer tutoring and discussion of the decision-making in the problem. This recommendation is equally applicable to all settings and ages of learners when positive group interaction patterns can be established.

To sustain participation, learners must see a clear link between what they are studying and a meaningful personal goal such as personal curiosity, personal advancement, work readiness, etc. Instructors should work individually with each learner to establish personal goals for the PLATO work.

It's also important for instructors to reinforce the message that work on PLATO is independent and empowering. It avoids the negative experiences of the classroom, and is a dignified, personal way to learn. Encourage learners to take responsibility for their own learning; PLATO is the tool which allows them to do this.

Demonstrate your own enthusiasm for the content being studied, and be a positive model for good learning practice.

In work environments, long-term participation will be best if learners are paid for their training time and/or do training during working hours.

PLATO Pathways can be set to permit progress to the next module whether or not the learner has passed the previous module's mastery test. This probably makes sense in most settings. However, learners often overestimate how well they understand something they have studied. Therefore, we recommend that learners be strongly encouraged or required to take the mastery tests (once) for all assigned modules (even if they don't feel they need the tutorials). Instructors who turn off the requirement to master before progressing usually believe their learners can make appropriate judgements about what to study and how long, and will use tests on their own to guide their progress, while using their judgement to skip irrelevant content. On the other hand, instructors who turn this feature on are usually concerned that learners will "cheat" by skipping ahead without taking mastery tests first.

If use of the mastery tests is considered too threatening or "childish," the instructor may assign only the tutorial and/or practice lessons within each module, and may encourage learners to skip modules they feel they fully understand. However, instructors who use this option should expect less consistent learning from the use of PLATO, even by well-motivated learners.

Instructors should help learners develop realistic expectations about their experience. Learning via PLATO is often more efficient than learning in a conventional classroom, but that doesn't make it a "quick fix." PLATO will allow the learners to move quickly

through what they already know, if the learners take and pass the mastery test for each assigned module even if they feel they don't need the tutorial or practice lessons, or if a report or project is the ultimate goal. Alternatively, if PLATO Pathways is set to allow full learner control, learners can simply select only the modules and activities of interest to them. Frustration is often an experience when doing problem-solving activities such as PLATO PSA's. Learners should be encouraged to see this as normal, and a stimulus to seek further knowledge/understanding or to change strategies.

Best results are obtained when the instructor monitors progress and adjusts the instructional prescription as needed. Particular "red flags" are:

- More than two hours spent on a module (other than a PSA)
- More than 2-3 tries on the mastery test
- Only 1 try on a tutorial, accompanied by more than an equal number of tries on the mastery test
- Very little time spent on tutorial lessons and practice accompanies by a large number of tries on mastery tests
- Learner questions or non-verbal signs of confusion or frustration; statements that it's "too hard," "too easy" or "boring."
- Abnormally slow or fast progress

Instructors noticing these "red flags" should intervene and "troubleshoot" the problem. Experience shown likely problems are often:

- Too many or too few prerequisite skills assumed by the PLATO assignments.
- Insufficient, or too infrequent, time on PLATO.
- Insufficient variety of on-line and off-line learning tasks.
- Use of a path based on the wrong alignment for the purpose, resulting in prescriptions to study modules which do not correspond to the current topic or learner interests.
- Playing the problem-solving activity mindlessly like an arcade game, without stopping to think about how to solve the problem.
- Insufficient connection for learners between their own personal goals and study on PLATO.
- Poor learner control decisions, such as skipping tutorials and re-taking a mastery test repeatedly to try to "beat the system" (*Pathways* can be set to allow only 3 tries on a mastery test).
- Inadequate skills in keyboarding or mouse usage, or "computer anxiety"
- Overconfidence or underconfidence
- Inadequate skills in reading or English, or an undiagnosed learning disability

- Lack of readiness to learn, due to unmet personal or family needs.

In this model, there is no requirement for computer activities to provide a complete, self-sufficient solution for any curriculum topic. However, it's especially true in language arts courses, where whole-skill practice of reading (especially out loud) and free-form writing are an important part of the curriculum but beyond what is possible with current technology. Note that this model is especially well-suited to integrated, interdisciplinary curriculum designs.

Instructors in this environment need to be fully familiar with the PLATO courses in use, and with the non-PLATO web sites or software included in the assigned paths.

RESOURCE MANAGEMENT

To optimize the opportunity for learner success one must take into account two variables:

1. the length of time of each session, and
2. the number of sessions per week, per subject.

For this model, we recommend:

The learner:computer ratio is 1:1 or 2:1 for the time each learner is using PLATO tutorial modules. Tests require a ratio of 1:1. PLATO PSA's and other online activities may be done using ratios of 1:1 to 4:1.

Figure an average of 30-45 minutes per module (if tutorial, practice and mastery test are all assigned), and multiply by the number of modules to be assigned. Add in an estimate of time required for additional Web site exploration or other non-PLATO activities. PLATO PSA's require 3-9 hours each to complete; add additional time when the problems are solved in teams.

Most programs find that a minimum time on the computer to assure adequate progress is 3 50-minute periods, though some programs have used as few as 2 periods per week. When scheduling learners to work on the computer, a useful "rule of thumb" for adults and young adults to avoid fatigue is not to allow more than 5 hours per subject per week on the computer. However, highly motivated learners have successfully spent upwards of 20 hours per week on the computer, if there is sufficient variety in the computer activities.

Thirty minutes of study in a tutorial module is considered average in many courses. If a learner spends more than one hour attempting to understand and master a module objective, the instructor should intervene with alternative sources of instruction to assist the learner.

Keep in mind that in this model it is *normal* to experience a 6:1 ratio of times to completion: what one learner can master in one hour will take another learner up to 6 hours to master. The scheduling system for computer time must be flexible enough to

allow this range, either by scheduling extra time during each week for the learners who need it, or by allowing flexibility in the number of weeks of study. Some programs also arrange for access to PLATO at home, in study periods, in library/media centers, after-school and weekend programs at community centers, and before and after school and in the evenings.

There is no requirement for the learners to all be in the same place at the same time, or to start or finish at the same time. If teams are used for the PSA's, the teams should be scheduled for computer access at the same time. Use of e-mail or conferencing technologies can also facilitate team communication, especially in distance education environments.

Instructor-learner contact can be done face-to-face or by any combination of telecommunications media.

In a 90-minute block scheduling environment, we recommend assignment of the whole block to the problem-solving unit (encompassing PSA's, tutorials, and other activities). Individual learners and teams will vary what they are working on considerably within and across periods. Large-group instruction, if any, should probably occur in the first half or so of the unit.

Work stations may be in a computer lab or in a work cluster in the classroom; or, learners may work on their own from a supervised location such as a library/media center or training room, or a quiet work room or at home. Any environment will work which allows teams to conveniently reach all learning resources, and to talk to each other and to the instructor.

In work environments, employees should be scheduled to work on PLATO during their shift, or before it if possible. Make sure there are no interruptions during study.

ASSESSMENT OF LEARNERS

Achievement is measured by portfolio assessment. The portfolio should include debriefing on PSA's, mastery tests on pre- and co-requisite knowledge and skills, and assessment of any additional assigned reports and projects.

Most PLATO PSA's include at least 3 variations. For mastery, learners should be able to successfully complete the problem with the Coach set to "Try it Myself" (uncoached mode).

In addition, most PLATO PSA's record a log of actions the learner made when solving the problem. This log can be printed, and compared on-line with a model "expert path" through the problem. By comparing the two logs, instructors can help learners identify strengths and weaknesses in their problem-solving performance and discuss why they occurred. Typical weaknesses include:

- Gathering too much or too little information
- Attempting problem-solving steps prematurely

- Too many actions (random guessing or poor formation of intermediate goals), such as mindlessly "plugging in the numbers."
- Jumping to conclusions (solving the problem before gathering the information needed)
- Trying to solve the problem without having mastery of prerequisite or corequisite skills, leading to oversights and inability to explain the rationale for solving the problem.

PSA's also have available a notepad, which can be saved and printed. It's often helpful to require learners to write down the strategy they are using and the rationale for each step. These entries then can be printed out and entered in the portfolio.

Some PSA's allow learners to print intermediate work products such as notes, memos, calculations, etc., generated with tools. This is primarily for their own use in discussing their work with others on their team. However, instructors may ask learners to print out and place such work products in their portfolios for discussion with the instructor and possibly for evaluation.

Progress on mastery of pre- and co-requisite knowledge and skills can be done using the mastery tests built into the PLATO modules. Evidence of timely mastery on module tests (within a reasonable number of tries) can be included as part of the learner's grade.

If additional work products such as reports are part of the portfolio, they should be scored by the instructor and/or peers, using a rubric constructed for the purpose.

If your program requires use of grades, you can base the grades on accomplishments such as number of modules mastered (within a reasonable number of tries), attainment of mastery goals (such as mastering the assigned modules by the end of the unit), efficiency and effectiveness in problem solving, or mastery of intermediate goals (milestones) toward a larger goal. Because tutorials are self-paced, we do not recommend use of time on task as an element in grading (though it may indicate a learner who is floundering), except as an "effort" indicator. Number of tries should not be used as the basis of a grade, because doing so can discourage exploratory activity.

Instructors who do not require mastery testing, may want to simply check that the "completed" flag is set for each assigned lesson.

Instructors who use tests for grading should remember that group work is not feasible for the tests and "try it myself" solution of PSA's, because of the requirement for test security. Group work may still be used for instructional activities.

Model #4: Skill Development

GOAL

The goal of this instructional model is to develop, remediate, and/or enhance the knowledge and skills of the learner using PLATO.

This is a particularly success-oriented model. In principle, anyone who is ready to learn can work until they have mastered each skill, in privacy. There is no comparison with peers—only with progress toward personal goals. Strictly speaking, in this model, failure is impossible—only non-completion.

When this model is fully implemented, evaluations have shown resulting learning gains can be substantial. Best results occur when a instructor who is fully familiar with PLATO is actively involved as a "guide on the side." However, this model is useable (with reduced results) in situations where no instructor is involved.

Because it requires a 1:1 learner:computer ratio and flexible, self-paced study using individualized learning plans, this model is popular in "mainstream" classrooms seeking to get away from large-group instruction. It also is popular in a broad range of specialized programs such as alternative schools, at-risk programs, accelerated learning programs, school-to-work programs, ESL and LD programs, as well as developmental studies and adult learning settings. It is particularly well suited for programs with high learner mobility or heterogeneous learner populations, because it provides an alternative to large-group instruction and emphasizes individualization. This model also is popular when accountability is an issue and underachievement is common. It is popular in charter schools because of its flexibility, and it is a good fit for many distance education programs.

This model may be used to teach prerequisite skills, leading into the problem-solving instructional model or the complementary instructional model.

PLACEMENT

This model assumes that every learner has a different profile of learning needs, so there is no single starting point for all learners. Furthermore, a principle of this model is that no learner should study a given module until all the prerequisites for that module have been mastered. Therefore, accurate placement is critical. It often is done is done by using a placement strategy which involves some kind of diagnostic/placement testing, though there are other options.

There are six ways to place a learner in PLATO:

An external standardized test based on the program goals. The score or score profile from the test will tell the instructor which program goals the learner has already mastered, and which need work. Then, the instructor can place the learner at the corresponding point in the PLATO path which is aligned with your curriculum by using PLATO Pathways to assign the learner to particular paths and then set exemptions for what has already been mastered. Programs which use standardized tests such as the SAT 9 or ITBS, adult basic skills tests such as CASAS or TABE, or which use state or district minimum competency tests, often do their placement this way. Note that the full *Work Keys* test is most commonly used after training rather than for placement.

A PLATO customized assessment based on the program goals. The custom test is built by you using the PLATO *Custom Assessment Tool* (CAT) using your selection of items from the PLATO item banks. It should contain a selection of test items that correspond to the PLATO path which is aligned to your program. The system will automatically exempt learners from modules for which they show mastery.

A course-level assessment (CLA) based on the standard PLATO published paths. These are tests we have built for each of the courses in our core skills curricula using the default learning path. The system will automatically exempt learners from modules for which they show mastery. Each CLA is about 20-30 minutes in length.

The PLATO FASTRACK placement tool. This is a short, criterion-referenced test used for basic level Math, Reading and Language Arts. It uses a "tailored testing" strategy to select what questions to ask based on the learner's performance and starting information you give it. It will automatically set exemptions to place learners in the default (published) PLATO learning paths for these curricula.

Module mastery tests. The instructor can start everyone at the same point in your path, and encourage learners to take each module mastery test first (once), and "place out of" modules they do not need to study.

Instructor judgement calls. The instructor can set exemptions and determine the individual starting point for every individual learner based on personal judgment of what the learner needs to study. Programs with their own existing placement test may prefer it to other options.

There are advantages and disadvantages to each strategy: These are summarized in the following table.

Placement Testing Strategy	Advantages	Disadvantages
External standardized basic skills test	Valid—referenced to generally recognized skill model Usually norm-referenced Best reliability May be needed for program requirement to report gains (e.g., by grade level)	Time consuming Costly Exemptions set manually May not precisely test all skills in the path
Custom CAT tests	Criterion-referenced Good reliability Based on your alignment	Time consuming You must build the test specifications Includes only PLATO items
Published CLA tests	Criterion-referenced Good reliability Based on published alignment; does not require custom alignment	Covers only core skills curricula Published (default) alignment; may not meet your needs Time consuming if all tests are used (20-30 minutes/ test)
FASTRACK	Criterion-referenced Short; east time-consuming Automatically sets exemptions	Fair reliability – designed to place people "low" Uses published core skills curriculum paths only Only for core reading, writing, math basic skills curricula
Module Mastery Tests	No time spent on individual pretesting or prescription: everyone starts at the same place Allows computer to dynamically adapt to learner performance as study occurs Most reliable assessment inventory of each individual skill Automatic	Learners must spend considerable time taking tests they will see as "easy" before reaching their skill level Learners can "cheat" by repeatedly retaking the test, unless you limit number of tries via PLATO Pathways.
Your own judgement calls based on your own	Simple – just set exemptions manually	Least reliable, unless you know the learner and PLATO curricula in great detail, or you have

Placement Testing Strategy	Advantages	Disadvantages
records from your own tests and assignments		carefully developed your own placement tests and aligned them to the PLATO alignment you are using.

Note that for EEO (Equal Employment Opportunity Act) reasons, PLATO tests are not designed to select people who qualify for training, nor should they be used to qualify people for employment or promotion. PLATO test records should not go into a central employment file; they should be part of a separate and private training record.

LEARNER ROLE

The learner's participation in the program should be self-paced, with start points set by the appropriate placement tests, and progress regulated by the PLATO module mastery tests. The learner is allowed to study at his/her own level of readiness until all required mastery tests have been passed. If you include the problem solving activities (PSA's) in an assigned path, the instructor will need to assign mastery (and set the mastery flag in PLATO Pathways) manually after having evaluated the work of each learner.

The learner:computer ratio is 1:1. All study can be private. However, you may wish to encourage peer tutoring (2:1 work) for tutorials and application lessons, and collaborative learning (at 4:1 or so) for PSA's. Placement and mastery tests, of course, should be taken in a 1:1 setting which is secure.

To help sustain motivation and improve understanding, a good strategy is to cluster learners together into "study groups" of 4 or 5, and encourage peer tutoring and collaborative learning. It's probably more important for the members of the group to share common goals, than it is for them to be at a similar ability level. This is particularly valuable for study of PSA's.

INSTRUCTOR ROLE and PROGRAM STRUCTURE

The instructor's role is that of a "guide on the side" rather than a "sage on the stage". There is little or no large-group instruction, since learners will be at widely different points in the curricula. This role allows the instructor to manage, facilitate, mentor, tutor, or counsel, as appropriate, to help each learner meet his/her instructional goals.

To sustain participation and effort:

- Learners must clearly understand exactly what they need to do and learn. PLATO lessons include such explanations, but make sure they are clear to the learners.
- Learners must see a clear link between what they are studying and a concrete, meaningful, and appropriately challenging personal goal such as graduation, GED equivalency, catching up to peers, work readiness, etc. Work individually with each learner to establish personal goals for the PLATO work.
- Reinforce the message that work on PLATO is independent and empowering. It avoids the negative experiences of the classroom, and is a dignified, personal way to learn. Encourage learners to take responsibility for their own learning; PLATO is the tool which allows them to do this.
- Do accurate placement, to correct overconfidence or underconfidence.
- Celebrate the learners' success. At all times, reinforce the message that "I can do this if I try." Notice the PLATO "Success" screens at the end of each lesson; print out and send home frequent progress reports. Keep the intervals of study and success short.
- Set a positive, work-oriented yet relaxed mood through comfortable and upbeat lighting, furniture, room decoration, and even soft instrumental music.
- Demonstrate your own enthusiasm for the content being studied, and be a positive model for good learning practice.
- If a learner appears not ready to learn (e.g., angry, depressed, ill, anxious, distracted or fatigued), intervene to determine the cause and work out a solution.
- In work environments, long-term participation will be best if learners are paid for their training time.

Set PLATO *Pathways* to permit progress to the next module only after passing the previous module's mastery test. Set *Pathways* so learners who fail the mastery test must enter the tutorial. When reviewing, encourage learners to use internal module menus to review only the point which was missed. However, keep in mind that this feature also allows learners to exit the tutorial at any time and retake the mastery test, so you may wish to set Pathways to limit the number of tries allowed on mastery tests. Instructors who limit the number of tries and require mastery are usually concerned that learners will "cheat" by skipping ahead without adequate study, simply by repeating the mastery tests and memorizing the questions (questions are randomly selected from a pool of 10-15 or more per module, to discourage this). Instructors who do not limit number of tries and allow learners to progress without mastery usually believe their learners can make appropriate judgements about what to study and how long, and will use tests on their own to guide their progress, while using their judgement to skip irrelevant content.

Be sure to help your learners develop realistic expectations about their experience. Learning anything of significance requires sustained work over a period of months, and mastering basic skills is no exception. Learning via PLATO is often more efficient than learning in a conventional classroom, but that doesn't make it a "quick fix." PLATO will allow the learners to move quickly through what they already know, so if the system appears to place the learner at a lower point than expected, it's important to explain

that it's just a way for the system to be cautious and make sure the learner has fully mastered prerequisites.

To build retention, use these strategies:

- Make sure all learners complete the application, practice and drill lessons
- Assign the application, practice and drill lessons for review, after a period of days or weeks has passed since the learners completed the tutorials and mastery tests.
- Assign the paper-based supplemental exercises, if any, in the instructor guides. You can assign them immediately as "homework" or "seatwork," or assign them after a delay of some weeks since on-line study of the same skills.
- Schedule on-line practice lessons and on-line course-level assessments and mastery tests for review just before major cumulative tests.

Use PLATO Pathways exception reports to monitor progress and adjust the instructional prescription as needed. Particular "red flags" are:

- More than two hours spent on a module
- More than 2-3 tries on the mastery test
- Only a few tries on a tutorial, accompanied by more than an equal number of tries on the mastery test
- Learner questions or non-verbal signs of confusion or frustration; statement's that it's "too hard," "too easy" or "boring."
- Abnormally slow or fast progress

If you notice these "red flags," immediately intervene and "troubleshoot" the problem. Experience has shown likely problems are often:

- Placement at the wrong point: too many or too few prerequisite skills assumed, resulting in assignments which are too easy or too hard, and leading to overconfidence or underconfidence.
- Insufficient, or too infrequent, time on PLATO, or too large a block of time in one sitting at the computer.
- Use of a path based on the wrong alignment for the purpose, resulting in prescriptions to study irrelevant modules.
- Failure to prescribe needed prerequisite modules.
- Insufficient connection for learners between their own personal goals and study on PLATO.
- Poor learner control decisions, such as skipping tutorials and re-taking a mastery test repeatedly to try to "beat the system" (Pathways can be set to limit tries on a mastery test).

- Poor connection to meaningful, concrete personal goals.
- Inadequate skills in keyboarding or using the mouse, or "computer anxiety."
- Inadequate skills in reading or English
- A feeling of helplessness or underconfidence, as in "I'm no good at this" or "they won't let me," usually based on past learning experiences.
- An external factor which is preventing the learner from being ready to learn, such as anxiety, depression, etc.
- Undiagnosed physical or learning disability.

Note that best results are generally obtained when an instructor is involved in teaching any course. However, it's especially true in language arts courses, where whole-skill practice of reading (especially out loud) and free-form writing are an important part of the curriculum but beyond what is possible with current technology.

You need to be fully familiar with the PLATO courses in use, and any program tests or requirements. Often, we find that the "learning curve" can span an entire year, and best results are achieved in the second or third year of the program.

Use a custom curriculum path which is based on an alignment of PLATO to the standards and external tests you use. We recommend use of the default path which includes the whole curriculum only if your program does not operate with any pre-defined standards or non-PLATO tests.

RESOURCE MANAGEMENT

To optimize the opportunity for learner success you must take into account two variables:

- the length of time of each work session and
- the number of sessions per week, per subject.

For this model, we recommend:

- The learner:computer ratio is 1:1 for the time each learner is on PLATO (although some activities work well at 2:1 or 4:1, as discussed above).
- Learners should attend <u>at least</u> two 30 minute sessions per week, per subject. Learner success typically peaks when a learner uses the computer up to three hours (periods) per day, across all subjects. A balance between the two is recommended - three 50-60 minute sessions per week, per subject. This can be interleaved with non-computer large-group or small-group complementary or problem-solving activities, such as projects. If you plan to interleave large-group presentation of new content, be sure to take into consideration that the learners will be spread out very widely across the curriculum due to the self-pacing in this model, so alignment of individual and classroom work will be difficult.

- Thirty minutes of study in a tutorial module is considered average for most PLATO courses (though there are exceptions). If a learner spends more than 90 minutes or so attempting to understand and master a module objective, intervene with alternative sources of instruction to assist the learner.

- Total time in a curriculum will vary according to placement level and learning rate. Learning rate varies over a ratio of 6:1 (one hour's learning for one individual will be 6 hour's learning for another). This means your scheduling system must be flexible enough to allow learners a wide range of time on the system: as little as a few weeks, or as much as 6 months or more, in a typical classroom. This can be done by allowing work beyond the semester, or by making PLATO available for additional work during study periods, before or after school, or at home via PLATO on the Internet.

There is no requirement for the learners to all be in the same place at the same time, or to start or finish at the same time. Open entry/open programs fit well with this model.

Instructor-learner contact can be done face-to-face or by any combination of telecommunications media.

In a 90-minute block scheduling environment, we recommend assignment of the whole block to PLATO study only for older, well-motivated learners. However, a "lab" setting where learners are encouraged to do peer tutoring or problem-solving activities and otherwise vary their tasks, can easily involve 90 minutes on the computer without fatigue.

Work stations may be in a computer lab or in a work cluster in the classroom; or, learners may work on their own from a supervised location such as a library/media center or training room, or a quiet work room or at home.

In work environments, employees should be scheduled to work on PLATO during their shift, or before it if possible.

In all environments, providing PLATO access for the whole family (a family literacy model) will often help sustain participation. There is no reason to ever turn off the PLATO system: it can be available 24 hours per day, 7 days per week, on site from work stations or accessed from a home computer.

ASSESSMENT OF LEARNERS

Mastery of program/learner goals is determined by one of the following assessments:

- An external proficiency test based on the program goals.

- A PLATO customized assessment based on the program goals.

- An off-line standardized test such as the ACT Work Keys Assessment. The test must be for the skill areas that correspond to the learners' course of study.

Grading. Grades often operate as punishment for underachieving learners. For this reason, remedial programs and alternative schools often opt not to use grades, or to allow a pass/fail system. However, if your program requires use of grades, you can base them on number of tutorial modules mastered, attainment of mastery goals, or mastery of intermediate goals (milestones) toward a larger goal. We do not recommend grading based on number of tries, since this creates a disincentive to review poorly understood materials. We also do not recommend ranking learners relative to each other, because this can be punishing for underachievers.

As you debrief with learners working on the PSA's, have them print out their work products note pads and logs, and use them for portfolio assessment.

Some instructors also allocate a small percentage of course grade to an "effort" index based on total time on task in relevant assignments per week, using the PLATO time reports. However, note that time in individual modules will vary widely and is not a suitable basis for grades.

Credit Hours. If your course is to receive academic credit, you will probably need to state how many credit hours (or Carnegie Units) your course is to be assigned. For a self-paced course, the usual guidelines concerning contact hours cannot apply. We recommend instead that you equate content in your course syllabus (and alignment and PLATO Path) to equivalent content in a conventional (non self-study) course, and assign the same number of units as the corresponding conventional course.

Selected college-level courses in PLATO have been reviewed by PONSI and recommended for award of college credit by post-secondary institutions.

Instructional Model Comparison Matrix

The table below compares the four models described here. You can use it to select the model which best meets your needs.

	Skill Development	Review/ Reinforcement	Enrichment/ Exploration	Problem-Solving
Goal	Develop, remediate, and/or enhance basic skills Failure is impossible, only non-completion	Reinforce previously-taught knowledge and skills. "Safety Net"	Provide additional knowledge and skills. "Independent study" for able learners.	Make problem-solving the central strand of the curriculum Authentic "applied" learning Emphasis on higher-order thinking skills
Placement	• External standardized test • CAT • CLA • *FASTRACK* • Mastery tests • Instructor judgment	• Instructor determined • Aligned to curriculum (not individual needs) • All learners work on the same topics at the same time	• Determined entirely by the structure of the course syllabus • No need to do placement testing • Learners may self-select PLATO modules • Based on	• PLATO alignments to PSA + CAT to verify mastery of prerequisites • CLA on prerequisites

	Skill Development	Review/ Reinforcement	Enrichment/ Exploration	Problem-Solving
			learners' interests	
Learner Role	• Fully self-paced • Start points set by placement tests • Progress regulated by PLATO mastery tests	• Self-pacing limited; class stays together • Individual or peer tutoring Study	• Self-paced within time allotted • Exploratory/ Independent study • Individual work or pairs for tutorials, groups of 4 for PSA's	• Self-paced within time allotted • Exploratory • Individual or groups up to 4 for PSA's & projects; individual or pairs for supporting tutorials
Instructor Role	• Facilitator • Little or no large group instruction • Mentor • Tutor • Counselor • Should work individually with each learner to establish personal goals for PLATO work	• Unchanged from "typical" classroom instruction • Content area expert • Teaching style least affected	• Teaching style slightly affected • Content area expert • Should work individually with each learner to establish personal goals for PLATO work	• Facilitator • Knowledgeable of pre-/co-requisites for PSA • Coach
Program Structure	• Individualized • Diagnostic/pre-scriptive • Highly structured	• Review pre-requisites • Provide additional reinforcement • Highly structured	• Loosely structured • Learner-driven/ exploratory • Build learning paths that combine PLATO lessons with Web sites, other instructional software and off-line activities	• "Top-down" or "Bottom-up" • Use with PLATO PSA's and/or non-PLATO problems/ projects • Tutorials support to teach pre- and co-requisites
Resource Manage-	• 1:1 ratio learner: computer	• 1:1 ratio learner:computer	• 1:1 or 2:1 for PLATO tutorial	• 1:1 for PLATO tutorial modules

	Skill Development	Review/ Reinforcement	Enrichment/ Exploration	Problem-Solving
ment	• Min. time= 2x30 minutes per week per subject • Max. time=5x50 minutes per week per subject	• Min. time= 2x30 minutes per week per subject • Max. time=3x50 minutes per week per subject	modules • Min. time= 2x30 minutes per week per subject • Max. time=5x50 minutes per week per subject	• 1:1 to 4:1 for PLATO PSA • Min. time= 2x30 minutes per week per subject • Max. time=5x50 minutes per week per subject • Min. 90 minutes/PSA
Assessment of Learner	• External tests • PCAT • Starndardized test	• Non-PLATO tests	• Reports and projects • Mastery tests • Completion/ participation	• Portfolio assessment • PLATO PSA in "uncoached mode" w/learner log compared to expert path • Mastery tests for tutorial work • Completion/ participation

Appendix A: Mastery Learning and PLATO

Mastery learning was first developed by Benjamin Bloom (of Taxonomy fame) in the 1970's. Although Bloom didn't make the distinction between instruction and instructional management, in retrospect it appears that his model was essentially of instructional management. The basic principles of mastery learning are simple but radically different from those of conventional classroom practice:

No learner begins study of a given subject until all the prerequisites have been mastered.

Learners must be allowed to study a given subject until they fully master it.

Learners need not study subjects they have already mastered.

Bloom's model advocated use of precise learning objectives to structure the curriculum. Frequent, short tests were used to control progress. The tests were to be *criterion-referenced* rather than *norm-referenced.* A criterion-referenced test measures fully the achievement of each objective, regardless of how hard or easy it is. A norm-referenced test is designed to assign a learner a percentile rank in a group of comparable learners.

Bloom found a number of interesting results[3]. Among them were:

- Learners performed about one standard deviation (32%) better under mastery learning than in conventional classes used as control groups. Achievement was spread over a "J"-shaped curve, rather than a bell-shaped curve, with over 80% over learners achieving mastery (in principle, a learner can never fail in mastery learning, only receive a grade of "incomplete.")
- The results were obtained in a wide range of schools, with a wide range of achievement levels and learner profiles.
- The range of completion times varied over a ratio of 6:1. In other words, with achievement held constant by the mastery learning model, a bell-shaped curve of completion times resulted. Thus, it seems that if we hold instructional time constant (as in a conventional school), we get a bell-shaped curve of achievement; if we hold achievment constant (as in a mastery learning class), we get a bell-shaped curve of instructional times.

[3] Bloom, B.S. (1976) *Human Characteristics and School Learning.* New York: McGraw-Hill.

- Most of the variation in achievement in conventional classrooms was correlated with variations in achievement at the beginning of the semester or year. In other words, the good learners did a little better, the bad learners did a little worse, and very few learners changed their relative rank in class. This effect was virtually eliminated in mastery learning classrooms.
- Overall self-efficacy by students (an attitude of "I can do this") improved. Learners commented that the lessons were "easy" (a logical result, since they started them when they were ready).

Mastery learning was installed in a number of model schools in the 1970's and early 1980's, but gradually fell into disuse.[4] In retrospect, we can speculate that this happened because of a general turning away from issues of accountability and achievement in that period, criticisms of simplistic curricula (a common criticism of the first-generation objectives-based curricula, whether or not mastery learning was involved), and mis-applications of the principles. But it seems likely that the main reason the systems were abandoned was the extraordinary work load placed on the instructor. Paper-and-pencil instructional management left the instructors with the nightly task of grading that days' tests and assignments, and making the prescriptions for the next day's work, individually for each learner. In addition, it's very hard to run a mastery-model classroom in the context of a conventional school. The complete individualization means that learners immediately "spread out" over the curriculum. Meaningful large-group instruction is nearly impossible. Even more perplexing for administrators is the 6:1 completion time ratio: some learners will finish the year's work in a few weeks, while others will require many additional weeks of study.

Another weakness of Bloom's original research was inattention to quality of instruction. Since he concentrated primarily on instructional management, instructors were generally left to their own devices to invent individual instructional assignments for each learner. Inevitably, the results were inconsistent at best. Bloom expressed frustration that while Mastery Learning could achieve a 1-sigma (one standard deviation, or 32%) improvement, a skilled tutor working 1-on-1 with a learner could achieve a 2-sigma improvement (an additional 16%). Subsequent research on design of instruction, incorporated into PLATO lessons, has gone far to overcome this limitation of Bloom's work.

There are many ways to use PLATO, as discussed in section 5, above and in *Technical Paper #6*. One of them, the skill development model, is an application of classical mastery learning principles. Many of the features of the architecture of PLATO are specifically designed to overcome the limitations of the original paper-and-pencil-based mastery learning programs. For example:

- Each tutorial lesson is accompanied by a short criterion-referenced mastery test.

[4] However, in the 1990's, a successful instructional model for elementary school reading which extended and built on Bloom's research were developed by Robert E. Slavin at Johns Hopinks University.

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